APPENDIX F-1

Qualitative Analysis Paper

The Total Allowable Catch-Setting Process

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ACRONYMS AND ABBREVIATIONS

ABC	acceptable biological catch
AFSC	Alaska Fisheries Science Center
AP	Advisory Panel
BSAI	Bering Sea/Aleutian Islands
Council	North Pacific Fishery Management Council or Council (NPFMC)
EC	ecosystem considerations
FMP	Fishery Management Plan
GOA	Gulf of Alaska
maxABC	maximum permissible level
MFMT	maximum fishing mortality threshold
MSA	Magnuson-Stevens Fishery Conservation and Management Act
MSST	minimum stock size threshold
MSY	maximum sustainable yield
mt	metric tons
NOAA Fisheries	National Marine Fisheries Service (NMFS)
NOAA	National Oceanic and Atmospheric Administration
NSGs	National Standard Guidelines
OFL	overfishing level
OY	optimum yield
SAFE	Stock Assessment and Fishery Evaluation
SCMC	structure and composition of management categories
SEIS	Supplemental Environmental Impact Statement
SSC	Scientific and Statistical Committee
TAC	total allowable catch

The Total Allowable Catch-Setting Process

1.0 Introduction

The Fishery Management Plans (FMPs) for the groundfish fisheries managed by the North Pacific Fishery Management Council (NPFMC) incorporate a complex suite of measures. These include harvest controls, effort controls, time and/or area closures, bycatch controls, monitoring and enforcement measures, and rules responding to other constraints (e.g., regulations to protect Steller sea lions and to avoid seabirds). This qualitative impact assessment provides a broad overview of four proposed management policies specifically as they pertain to harvest control or the Total Allowable Catch (TAC)-setting process in the Bering Sea/Aleutian Islands (BSAI) and Gulf of Alaska (GOA) groundfish fisheries of the North Pacific. Its goal is to provide the reader with a basic understanding of each of four proposed policy alternatives regarding how TACs are now set and might be set in the future, and a qualitative assessment of the biological, physical, and socioeconomic consequences of each of these alternatives in relative isolation to other FMP components.

Before proceeding with the description and qualitative analysis of the four FMP alternatives under consideration, some background on the harvest strategy practiced by the NPFMC is provided. This background begins with a description of some of the key elements of the Magnuson-Stevens Fishery Conservation and Management Act (MSA) and the National Standard Guidelines (NSGs). It then provides an overview of the NPFMC's harvest strategy as it relates to the requirements of the MSA and NSGs.

2.0 Background on Harvest Controls

2.1 MSA Requirements

From the perspective of the TAC-setting process, the most important part of the MSA is National Standard 1, which states, "Conservation and management measures shall prevent overfishing while achieving, on a continuing basis, the optimum yield (OY) from each fishery for the United States fishing industry (emphasis added)." The MSA defines overfishing to mean "a rate or level of fishing mortality that jeopardizes the capacity of a fishery to produce the maximum sustainable yield on a continuing basis." The MSA defines OY as the amount of fish which:

- "will provide the greatest overall benefit to the Nation, particularly with respect to food production and recreational opportunities, and taking into account the protection of marine ecosystems;
- "is prescribed as such on the basis of the maximum sustainable yield from the fishery, as reduced by any relevant economic, social, or ecological factor; and
- "in the case of an overfished fishery, provides for rebuilding to a level consistent with producing the maximum sustainable yield in such fishery."

Note that the definitions of both overfishing and optimum yield refer to maximum sustainable yield (MSY). The MSA does not define MSY, but the NSGs define it as "the largest long-term average catch or yield that can be taken from a stock or stock complex under prevailing ecological and environmental conditions." The NSGs also introduce the concept of the "MSY control rule," defined as "a harvest strategy which, if

implemented, would be expected to result in a long-term average catch approximating MSY." The MSY control rule can take a wide variety of forms. The NSGs offer the following advice regarding MSY control rules:

> *In choosing an MSY control rule, NPFMCs should be guided by the characteristics of the fishery, the FMP's objectives, and the best scientific information available. The simplest MSY control rule is to remove a constant catch in each year that the estimated stock size exceeds an appropriate lower bound, where this catch is chosen so as to maximize the resulting long-term average yield. Other examples include the following: Remove a constant fraction of the biomass in each year, where this fraction is chosen so as to maximize the resulting long-term average yield; allow a constant level of escapement in each year, where this level is chosen so as to maximize the resulting long-term average yield; vary the fishing mortality rate as a continuous function of stock size, where the parameters of this function are constant and chosen so as to maximize the resulting long-term average yield. In any MSY control rule, a given stock size is associated with a given level of fishing mortality and a given level of potential harvest, where the long-term average of these potential harvests provides an estimate of MSY.*

Under the NSGs, the MSY control rule plays a key role in making the MSA's definitions of overfishing and OY operational. In the case of overfishing, the MSY control rule serves as an upper limit on permissible specifications of the "maximum fishing mortality threshold" (MFMT). The MFMT specifies the fishing mortality rate (F) above which overfishing is defined to be occurring (i.e., if F>MFMT, overfishing is occurring). The MFMT, in turn, plays a role in defining the "minimum stock size threshold" (MSST). The MSST specifies the biomass (B) below which the stock is defined to be overfished (i.e., if B<MSST, the stock is overfished). Specifically, the MSST is defined as whichever of the following is greater: one-half the MSY stock size, or the minimum stock size at which rebuilding to the MSY level would be expected to occur within 10 years if the stock or stock complex were exploited at the MFMT. Taken together, the MFMT and MSST constitute the set of "status determination criteria" which the NSGs require each FMP to specify whenever possible.

In the case of OY, the MSY control rule is key to interpreting the MSA's requirement that OY must be prescribed "on the basis of the MSY from the fishery, as reduced by any relevant economic, social, or ecological factor." According to the NSGs, this requirement means, in part, that the OY in any given year "must always be less than or equal to the harvest level that would be obtained under the MSY control rule." Therefore, if the MSY control rule were of the "constant catch" form, then a constant OY might be permissible, but if the MSY control rule were to associate different levels of catch with different stock sizes, then a constant OY would not be permissible (unless, perhaps, OY was set very conservatively).

2.2 NPFMC Harvest Strategy

Harvests in the BSAI and GOA groundfish fisheries are governed by the two FMPs, which constitute the overall "harvest strategy." The NPFMC harvest strategy is complex and multi-faceted because it must address a myriad of issues related to sustainability, legislative mandates, and quality of information. This section presents a fairly detailed overview of the various elements that comprised the NPFMC harvest strategy as reflected in the FMPs. In later sections dealing with comparisons between alternatives and example FMPs (e.g. the FMP "bookends"), attention will be focused more narrowly on those particular elements of the harvest strategy that differ between two or more alternatives.

2.3 Structure and Composition of Management Categories

The FMPs define four management categories for which catch is constrained by various regulatory mechanisms: Target Species, Prohibited Species, Other Species, and Forage Fish Species. In addition to these four management categories, the FMPs define a "Nonspecified Species" category for which catch is not constrained by any regulatory mechanism. Stocks can be moved from one management category into another only by FMP amendment. The five management categories are described below.

Target Species are those species which are commercially important and for which a sufficient database exists that allows each to be managed on its own biological merits. Within the Target Species category, stocks are managed either individually or as part of a stock complex. Stocks within the Target Species category can be added to or removed from a stock complex within the same category as part of the TAC-setting process (i.e., without an FMP amendment). Catch of each species or complex must be recorded and reported. This category includes species such as walleye pollock, Pacific cod, sablefish, flathead sole, and Pacific ocean perch.

Prohibited Species are those species and species groups that, when caught, must be returned to sea with a minimum of injury except when their retention is authorized by other applicable law. Groundfish species and species groups under the FMP for which quotas have been achieved are treated in the same manner as prohibited species. This category includes species such as Pacific halibut, herring, and Pacific salmon.

Other Species are species groups that currently are of slight economic value and not generally targeted upon. This category, however, contains species with economic potential or which are important ecosystem components, but for which sufficient data are lacking to be managed separately. Catch of this category as a whole must be recorded and reported. This category includes species groups such as sharks, skates, sculpins, and octopus.

Forage Fish Species are those species not included in the target species category and which are a critical food source for many marine mammal, seabird, and fish species. The forage fish species category is established to allow for the management of these species in a manner that prevents the development of a commercial directed fishery for forage fish. Management measures for this species category are specified in regulations and may include such measures as prohibitions on directed fishing, limitations on allowable bycatch retention amounts, or limitations on the sale, barter, trade, or any other commercial exchange, as well as the processing of forage fish in a commercial processing facility. This category includes species such as capelin, eulachon, and smelts.

Nonspecified Species are those species and species groups of no current economic value taken by the groundfish fishery only as an incidental catch in the target fisheries. Virtually no data exists that would allow population assessments. No record of catch is necessary. This category includes those species that do not fall into any of the other categories.

2.4 Overfishing and Acceptable Biological Catch

The overfishing level (OFL) constitutes an absolute upper limit on the amount of fish that can be taken from a stock or stock complex in a given year, and is prescribed by an explicit set of formulae in the FMPs. The acceptable biological catch (ABC) is a preliminary description of the acceptable harvest (or range of harvests)

for a given stock or stock complex. Its derivation focuses on the status and dynamics of the stock, environmental conditions, other ecological factors, and prevailing technological characteristics of the fishery. The ABC cannot exceed a maximum permissible level (maxABC), which is prescribed by an explicit set of formulae in the FMPs. In all cases, maxABC, and therefore ABC, is less than OFL. Strictly speaking, the only constraint that the FMPs impose on TACs is that their sum must fall within the OY range, meaning that, in principle, an individual TAC could be set higher than, equal to, or lower than the corresponding ABC. In practice, however, each individual TAC is always set equal to or lower than the corresponding ABC. Reasons for setting an individual TAC below the corresponding ABC may include various social, economic, or ecological considerations as well as the need to keep the sum of the TACs within the OY range. The following table describes the relationships between OFL, maxABC, ABC, TAC, the sum of the TACs ($\sum$TAC) and OY in the current system.

Quantity	Constraints imposed by FMP	Traditional, voluntary constraints
OFL	Value is prescribed by formula	None
maxABC	Value is prescribed by formula (always less than OFL)	None
ABC	$0 \leq$ ABC $\leq$ maxABC	None
TAC	$0 \leq$ TAC $\leq$ upper OY	TAC $\leq$ ABC
$\sum$TAC	lower OY $\leq$ $\sum$TAC $\leq$ upper OY	None

The formal, quantitative methods for determining OFL and ABC begin with the assignment of each stock to one of six "tiers" based on the availability of information about that stock (Table 1). Tier 1 has the greatest informational requirements and Tier 6 has the least. Each tier contains a formula or set of formulae defining OFL and another formula or set of formulae defining maxABC. In Tiers 1-5, OFL and maxABC are defined in terms of their respective fishing mortality rates, F_{OFL} and *max* F_{ABC}. In Tier 6, OFL and maxABC are defined directly (i.e., in terms of catch rather than a fishing mortality rate). The OFL formulae correspond to the MFMT required by the NSGs. The current formulae were introduced as part of Amendment 56 to each of the FMPs, adopted by the NPFMC in June 1998 and implemented on March 8, 1999. The formulae make use of several biological reference points, which are defined below:

F_{MSY} the fishing mortality rate at which long-term average yield would be maximized if the MSY control rule were of the "constant F" form

B_{MSY} the long-term average size of the stock or stock complex, measured in terms of spawning biomass or other appropriate units, that would be achieved under an MSY control rule of the "constant F" form

μ_A the arithmetic mean (i.e., average) of the distribution of the estimate of F_{MSY}

μ_H the harmonic mean of the distribution of the estimate of F_{MSY}

$F_{35\%}$ the fishing mortality rate at which the equilibrium level of spawning per recruit would be reduced to 35 percent of the equilibrium level of spawning per recruit in the absence of any fishing

$F_{40\%}$ the fishing mortality rate at which the equilibrium level of spawning per recruit would be reduced to 40 percent of the equilibrium level of spawning per recruit in the absence of any fishing

$B_{40\%}$ the long-term average biomass that would be expected under average recruitment when the stock is harvested at a fishing mortality rate equal to $F_{40\%}$

M the natural mortality rate

Tier 1 is used in those cases where the distribution of the estimate of F_{MSY} has been computed reliably. In this tier, F_{OFL} is set equal to the arithmetic mean of the distribution (the "risk neutral" point estimate) and *max* F_{ABC} is set equal to the harmonic mean of the distribution whenever biomass exceeds B_{MSY}. The harmonic mean has the mathematical property that it is less than the arithmetic mean by an amount that increases with the spread of the distribution, thus establishing a margin between F_{OFL} and *max* F_{ABC} that increases with the uncertainty surrounding the estimate of F_{MSY}. For levels of biomass below B_{MSY}, both F_{OFL} and *max* F_{ABC} decline linearly down to an intercept, below which both F_{OFL} and *max* F_{ABC} are zero (Figure 1). The default value for the intercept in Tier 1 is 5 percent of B_{MSY}, although the Scientific and Statistical Committee (SSC) can set a different intercept if warranted by the best scientific information available. Only one stock, EBS pollock, is currently assigned to Tier 1.

Table 1 The NPFMC Tier System Developed by the AFSC as Defined by FMP Amendment 56/56, June 1998.

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1) Information available: Reliable point estimates of B and B_{MSY} and reliable pdf of F_{MSY}.
   1a) Stock status: $B/B_{MSY} > 1$
   $F_{OFL} = \mu A$, the arithmetic mean of the pdf
   $F_{ABC} = \mu H$, the harmonic mean of the pdf
   1b) Stock status: $\alpha < B/B_{MSY} = 1$
   $F_{OFL} = \mu A \times (B/B_{MSY} - \alpha)/(1-\alpha)$
   $F_{ABC} = \mu H \times (B/B_{MSY} - \alpha)/(1-\alpha)$
   1c) Stock status: $B/B_{MSY} = \alpha$
   $F_{OFL} = 0$
   $F_{ABC} = 0$
2) Information available: Reliable point estimates of B, B_{MSY}, F_{MSY}, $F_{35\%}$, and $F_{40\%}$.
   2a) Stock status: $B/B_{MSY} > 1$
   $F_{OFL} = F_{MSY}$
   $F_{ABC} = F_{MSY} \times (F_{40\%}/F_{35\%})$
   2b) Stock status: $a < B/B_{MSY} = 1$
   $F_{OFL} = F_{MSY} \times (B/B_{MSY} - a)/(1-\alpha)$
   $F_{ABC} = F_{MSY} \times (F_{40\%}/F_{35\%}) \times (B/B_{MSY} - \alpha)/(1-\alpha)$
   2c) Stock status: $B/B_{MSY} = \alpha$
   $F_{OFL} = 0$
   $F_{ABC} = 0$
3) Information available: Reliable point estimates of B, $B_{40\%}$, $F_{35\%}$, and $F_{40\%}$.
   3a) Stock status: $B/B_{40\%} > 1$
   $F_{OFL} = F_{35\%}$
   $F_{ABC} = F_{40\%}$
   3b) Stock status: $\alpha < B/B_{MSY} = 1$
   $F_{OFL} = F_{35\%} \times (B/B_{40\%} - \alpha)/(1-\alpha)$
   $F_{ABC} = F_{40\%} \times (B/B_{40\%} - \alpha)/(1-\alpha)$

Table 1 The NPFMC Tier System Developed by the AFSC as Defined by FMP Amendment 56/56, June 1998.

3c) Stock status: $B/B_{40\%} = \alpha$

$F_{OFL} = 0$

$F_{ABC} = 0$

4) Information available: Reliable point estimates of B, $F_{35\%}$, and $F_{40\%}$.

$F_{OFL} = F_{35\%}$

$F_{ABC} = F_{40\%}$

5) Information available: Reliable point estimates of B and natural mortality rate M.

$F_{OFL} = M$

$F_{ABC} = 0.75 \times M$

6) Information available: Reliable catch history from 1978 through 1995.

OFL = the average catch from 1978 through 1995, unless an alternative value is established by the SSC on the basis of the best available scientific information.

$ABC = 0.75 \times OFL$

Tier 2 differs from Tier 1 in that only *point estimates* of the key population parameters are available; that is, the distribution of the estimate of F_{MSY} is not known. For a Tier 2 stock whose biomass is above B_{MSY}, F_{OFL} is set equal to the point estimate of F_{MSY}, much as in Tier 1, but a different formula (based on the adjustment used in Tier 3—see next paragraph) is used for adjusting the *max* F_{ABC} downward from F_{OFL}.

Tier 3 differs from Tiers 1-2 in that the available information is insufficient for any estimation of MSY. For a Tier 3 stock whose biomass is above $B_{40\%}$, F_{OFL} is set equal to the point estimate of $F_{35\%}$ and *max* F_{ABC} is set equal to the point estimate of $F_{40\%}$. According to the environmental assessment for Amendment 56, the $F_{35\%}$ reference point was intended to serve as a proxy for F_{MSY} (it was the *only* F_{MSY} proxy identified as such in the environmental assessment). Nearly all of the major target stocks in the BSAI/GOA are in Tier 3. Like the control rules for Tiers 1-2, the control rules for Tier 3 decrease linearly with biomass when biomass is below a tier-specific reference level, which is $B_{40\%}$ in the case of Tier 3.

Tier 4 differs from Tier 3 in that information is insufficient for estimation of reference biomass levels. In this Tier, F_{OFL} is set equal to the point estimate of $F_{35\%}$ and *max* F_{ABC} is set equal to the point estimate of $F_{40\%}$, regardless of biomass (i.e., the form of the control rules shown in Figure 1 does not apply to Tier 4).

Tier 5 differs from Tier 4 in that information is insufficient for estimating $F_{40\%}$ or $F_{35\%}$. In this Tier, F_{OFL} is set equal to the point estimate of the natural mortality rate (M), and *max* F_{ABC} is set equal to three fourths of that value, regardless of biomass (as in Tier 4).

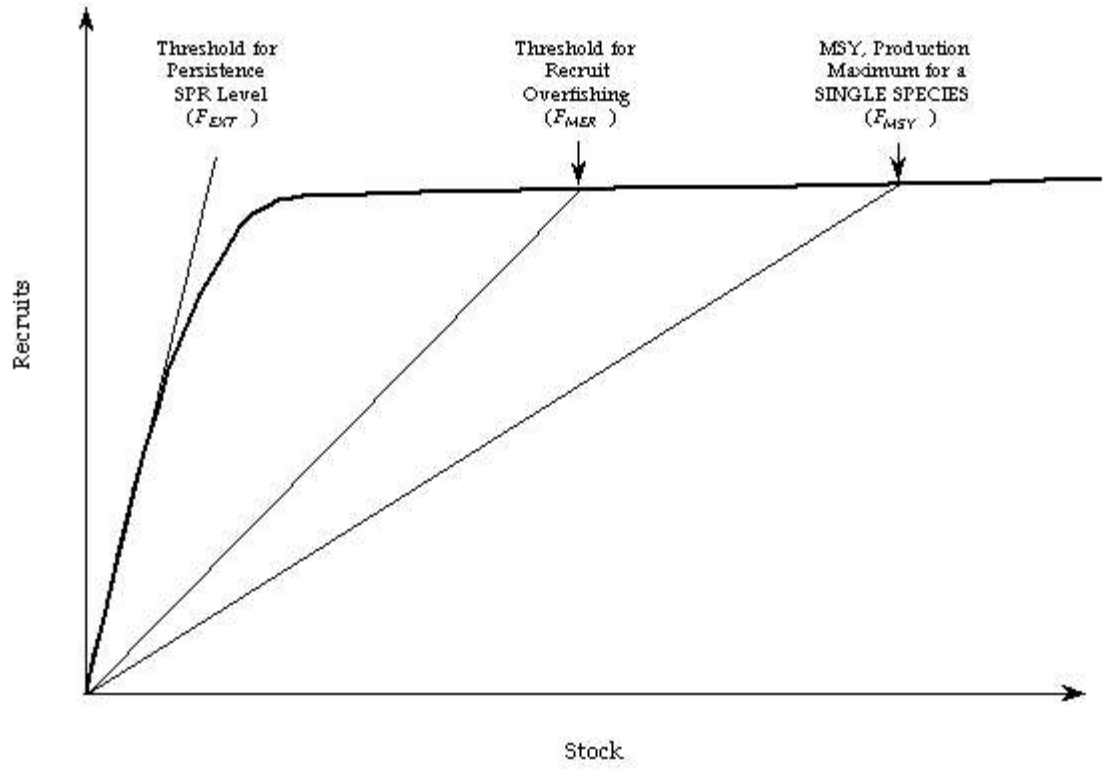

Figure 1. Some key fishery management thresholds. Thresholds are shown relative to fishing mortality vectors plotted on a Beverton-Holt type stock recruitment curve. F_{EXT} is the extinction mortality rate. Theoretically, a sustainable fishery could be maintained at this level but there would be no room for error in stock management. F_{MER} (Maximum Excess Recruitment) is also called *MSY* recruitment. Fishing at this level ensures maximum excess recruits to the fishery, but does not allow for maximum yield per recruit. *MSY* stock levels are required under the MSA. Fishing at the F_{MSY} level attains both maximum excess recruits and maximum yield per recruit. It also provides a greater margin of safety in that the stock is maintained at a larger size.

Tier 6 differs from Tier 5 in that information is insufficient for estimating any of the stock parameters, and all that is known is the catch history. In this Tier, OFL is either the average historic catch from 1978 through 1995 or an alternative value established by the SSC on the basis of the best available scientific information, and maxABC is three fourths of OFL, regardless of biomass (as in Tiers 4-5).

2.5 Optimum Yield and Total Allowable Catch

Another element of the NPFMC's harvest strategy is the specification of OY and TAC. The FMPs specify OY as a constant range of total (i.e., across-species) harvest levels. The range for the BSAI is 1.4 to 2.0 million metric tons (mt); and the range for the GOA is 116 to 800 thousand mt. Within the Target Species category, a separate TAC is specified annually for each individually managed stock and each stock complex. A single TAC is specified annually for the entire Other Species category. No TAC is specified for the Prohibited Species, Forage Fish Species, or Nonspecified Species categories. Although the FMPs require the sum of the individual TACs to fall within the OY range, they do not otherwise constrain individual TACs. In practice, however, individual TACs are never set higher than the corresponding ABCs. The FMP gives the Regional Administrator authority to close an area to directed fishing for a stock or stock complex whose remaining TAC is needed as bycatch in other directed fisheries. If a TAC is reached, the FMP requires the Regional Administrator to publish a notice declaring that stock or stock complex to be prohibited, in which case any further catches of that stock or stock complex must be discarded. In practice, National Marine Fisheries Service (NOAA Fisheries) attempts to manage each fishery so that total catch (including all discards) is less than, but very close to, TAC. When a directed fishery is closed, bycatch of that stock is limited by a maximum retainable bycatch, which is determined as a percentage of retained catch. If it appears that a TAC may be exceeded due to unanticipated circumstances and ABC is being approached, the managers typically prohibit retention of that species in all fisheries, in order to eliminate "topping off." If ABC is exceeded and OFL is being approached, the managers can prohibit or close any fisheries that might possibly take that species as bycatch.

Originally, OYs were specified for each stock and stock complex in the Target Species category and for the Other Species category. The OYs were derived from MSYs provided by NOAA Fisheries scientists from the Alaska Fisheries Science Center (AFSC) and reviewed by the SSC. Essentially, the approach was a constant catch strategy, which was intended to be updated whenever new information indicated that a change was needed. Because data and sophisticated analytical tools were relatively scarce by today's standards, the stock assessments were fairly simple, often estimating MSY as the product of the most recent survey biomass estimate and half the natural mortality rate. Furthermore, the early assessments were based on data taken during a period of time that is now believed to have been a point of low productivity in the two regions.

The NPFMC soon learned that the FMP amendment process as established by the MSA was not prepared to deal with annual changes in OYs that were specified as fixed numerical values in the FMPs. Each change in OY required a plan amendment, which took several months to put into place. Yet the assessed status of the population could change dramatically due to new survey and catch data, recruitment variability, and other changes in population parameters. The FMPs were amended several times to make such changes, but a better solution was needed.

The solution the NPFMC chose was to specify OY as a constant (i.e., biomass-independent) range for each of the two groundfish complexes. The summed TACs of all species in the Target Species and Other Species categories would have to be within the range, but the individual TACs could be adjusted annually through a specifications process (i.e., a plan amendment would not be required). Amendment 1 to the BSAI FMP,

which was implemented on January 1, 1984, set the OY range for the BSAI at 1.4-2.0 million mt (Amendments 1a, 2, 3, 4, and 7 were actually implemented earlier than Amendment 1). The OY range was set equal to 85 percent of the range of the summed species-specific MSYs in the BSAI. This range was chosen, in part, to insure that future harvests would be sustainable. Also, the final environmental impact statement for the BSAI FMP (dated August, 1981), which also covered Amendment 1, stated that use of the 85 percent multiplier was "intended both to assure the continued health of the target species themselves and to mitigate the impact of commercial groundfish operations on other elements of the natural environment." Thus, at the time it was specified, the BSAI OY range was believed to be conservative from both single-species and ecosystem perspectives.

Amendment 15 to the GOA FMP, which was implemented on April 8, 1987, set the OY range for the GOA at 116,000 to 800,000 mt. The upper end of the OY range was below the range of the summed species-specific MSYs in the GOA (805,000-1,000,000 mt). The lower end of the OY range was near the lowest historical catch over the period 1965-1985 (116,053 mt, taken in 1971). At the time of the lowest historical catch, pollock, cod, and Atka mackerel abundances were at low levels of abundance and, consequently, it was thought unlikely that catches lower than this value would be necessary during future instances of low abundance. The upper limit was selected in consideration of the volatility in pollock and flounder ABCs, the potential for harvesting at MSY, and the desire to allow for some moderate expansion in future flounder fisheries.

2.6 Minimum Stock Size Threshold

As noted above, the NSGs provide a standard definition of MSST, the criterion used to determine whether a stock or stock complex is overfished in the sense of the MSA. The NSGs require FMPs to specify MSST whenever possible. However, the BSAI and GOA Groundfish FMPs do not specify MSST. This has been a continuing source of confusion and controversy ever since the development of Amendment 56 (see Goodman *et al.* (2002) for a history). Although the FMPs do not specify MSST, the status of each stock in Tiers 1-3 is examined annually in the Stock Assessment and Fishery Evaluation (SAFE) reports with respect to the MSST definition contained in the NSGs. Based on this examination, no BSAI or GOA groundfish stock or stock complex managed under Tiers 1-3 is currently overfished. However, in the event that a stock or stock complex becomes overfished in the future, Tiers 1-3 contain provisions for "accelerated" rebuilding, meaning that reductions in both F_{OFL} and *max* F_{ABC} are triggered whenever the estimate of stock biomass is below a tier-specific reference level (Figure 1). In Tiers 1-2, the reference level is B_{MSY}, and in Tier 3, the reference level is $B_{40\%}$. For the purpose of determining whether a stock is "overfished," the NSGs set the rebuilding target equal to B_{MSY}. An estimate of B_{MSY} is available for Tiers 1 and 2 by definition. For Tier 3, the FMPs do not specify a B_{MSY} proxy, but the AFSC has traditionally used $B_{35\%}$ as the B_{MSY} proxy for Tier 3 stocks. The accelerated rebuilding schedule built into Tiers 1-3 may render specification of an MSST superfluous from a practical standpoint, because the management actions required for a stock which falls below its MSST may be identical to those that would take place automatically under the tier system.

Because it is not possible to estimate either B_{MSY} or any reliable proxy for B_{MSY} in Tiers 4-5, it is not possible to tell whether a stock or stock complex managed under either of these two tiers is currently overfished. Although Tiers 4-5 do not contain provisions for accelerated rebuilding, they *do* contain provisions for rebuilding under a constant fishing mortality rate. Thus, in the long run, stocks in Tiers 4-5 should tend toward the equilibrium biomass associated with the rate at which they are fished, but it is not possible to tell whether they have arrived at that equilibrium biomass or when they will get there. However, because biomass

estimates are available for stocks in Tiers 4-5, it is at least possible to tell whether stocks managed under these tiers are increasing or decreasing over time.

As with Tiers 4-5, it is not possible to tell whether a stock or stock complex managed under Tier 6 is currently overfished. Unlike Tiers 4-5, Tier 6 does not contain provisions for rebuilding under a constant fishing mortality rate, but it does contain provisions for rebuilding under a constant catch level. Thus, in the long run, stocks in Tier 6 should tend toward the equilibrium biomass associated with the average catch so long as that catch is sustainable, but it is not possible to tell whether they have arrived at that equilibrium biomass or when they will get there. Furthermore, because biomass estimates are unavailable for stocks in Tier 6, it may not be possible to tell whether stocks managed under this tier are increasing or decreasing over time, unless measures such as commercial catch per unit effort are deemed to be reliable indicators of relative biomass.

2.7 Ecosystem Considerations in the TAC-Setting Process

Most of the above elements of the existing harvest strategy have implications for the ecosystem, at least indirectly. A few, such as the BSAI OY range, were adopted with ecosystem considerations (EC) explicitly in mind. Some other elements of the existing harvest strategy address EC directly. For example, since 1998, the existing policy has included provisions for protecting forage species. Forage species are generally small, abundant fishes (also krill) that are preyed upon by marine mammals, seabirds, and commercially important groundfish species. They are believed to perform a critical role in the BSAI and GOA ecosystems by providing transfer of energy from primary or secondary producers to higher trophic levels. Forage species have been estimated to comprise the principal diet for more than two-thirds of Alaska seabirds and are critical to many seabirds for raising their nestlings. Forage species have also been recognized as important prey items for a variety of marine mammals including the Steller sea lion, northern fur seal, spotted seal, bearded seal, humpback whale, and fin whale. They are presently relegated to bycatch-only status in the groundfish fishery. Maximum retainable bycatch limits are set at 2 percent for the entire group of forage species, regardless of the composition of the forage species taken. This percentage defines the maximum catch of forage species that may be retained onboard a vessel relative to amounts of other retained species open to directed fisheries. Forage fish taken within the 2 percent limit may be used for commercial purposes and are typically processed into fish meal. During the period 1997-1999, an average of 39 mt of forage species was taken annually in the BSAI region and an average of 61 mt was taken in the GOA.

Another example is the NPFMC's encouragement of ecosystem research and development of ecosystem-based management policies. An Ecosystem Committee was established by the NPFMC in 1995 and has developed a draft policy for ecosystem-based management of North Pacific fisheries (Witherell *et al.* 2000). The EC section of the SAFE reports continues to become more substantial. Multi-species modeling efforts have been undertaken, mainly by AFSC personnel, and are being used as a primary analytical tool in this Programmatic Supplemental Environmental Impact Statement (SEIS). These models have allowed consideration of ecosystem impacts in ways that single-species models cannot (Goodman *et al.* 2002). Currently, these models are not viewed as a replacement for the single-species approach, but rather as a means of gaining better insight regarding potential ecosystem effects. The present FMP policy includes the goal of developing ecosystem indicators for future use in TAC setting, and the existing policy allows TAC to be set below ABC for a wide variety of reasons including EC.

A third example focuses on the groundfish species that figure most prominently in the diet of Steller sea lions: walleye pollock, Pacific cod, and Atka mackerel. In 2000, a Biological Opinion prepared under Section 7

of the Endangered Species Act on all aspects of the FMPs concluded that fisheries for these species jeopardized the continued existence of Steller sea lions and adversely modified their critical habitat due to competition for prey and modification of their prey field. To mitigate these effects, regulations now require, among other things, that the directed fishery for any stock of these species be closed if the biomass of that stock is projected to be less than or equal to $B_{20\%}$ (the long-term average biomass that would be expected under average recruitment when the stock is harvested at a fishing mortality rate equal to $F_{20\%}$) during the fishing year.

Many other aspects of the FMPs (e.g., Prohibited Species caps) also deal with EC, but they are not as directly related to the TAC-setting policy as the above items and so are dealt with in other chapters of this appendix.

2.8 Annual Cycle

The TAC-setting process follows a regular annual cycle. Each year, scientists from the AFSC and the Alaska Department of Fish and Game collect data and compile and update databases on catch, age and size composition, and survey biomass. Stock assessment scientists from these agencies analyze the data and calculate estimates of population parameters, biomass, and age structure. Stock assessment models are used to integrate the scientific information, except when information is not sufficient to construct such a model. The processes of stock assessment and harvest strategy development are interrelated. Stock assessment models are used in development of the harvest strategy, and the current NPFMC biomass-based harvest strategy utilizes the most recent biomass estimates in determining ABC, OFL, and TAC.

The BSAI and GOA Plan Teams meet in September to discuss general methodological issues and any preliminary stock assessments that have been prepared. The SSC, the Advisory Panel (AP), and the NPFMC meet in October. The SSC focuses on assessment methodology, while the AP recommends and the NPFMC sets preliminary TACs based on extrapolations from the previous year. By November, the individual chapters of the SAFE reports have been prepared by the assessment scientists and another group of scientists has completed the EC section. The Plan Teams meet again in November to review the SAFE reports and make ABC and OFL recommendations. In December, the SSC reviews the SAFE reports and Plan Team recommendations, then formulates its own ABC and OFL recommendations. The AP recommends TAC values, traditionally lower than the ABC values recommended by the SSC. The NPFMC then sets final values of ABC, OFL, and TAC, subject to confirmation by NOAA Fisheries.

3.0 FMP Policy Alternatives

Four FMP policy alternatives are under consideration by the NPFMC. Alternative 1 is the present policy. Each policy alternative contains two bookends to a range of management measures that illustrate how the framework could be implemented. These bookends provide a level of detail that allows analysis and provides contrastable policies. They also provide a means to commit the NPFMC action in implementing an alternative, while allowing the NPFMC, under the MSA, the flexibility to adaptively manage the fishery through FMP amendments.

Alternative 1 Continue Management Under Existing (Updated) Policy: Under this alternative, the NPFMC would continue to manage the groundfish fisheries based upon the present conservative and risk-averse policy. This policy assumes that fishing does result in some adverse impacts to the environment and that, as these impacts become known, mitigation measures will be

developed and appropriate FMP amendments will be implemented. The objectives of this policy are to: adopt conservative harvest levels for single species fisheries and specify OY; continue to use existing OY cap for BSAI and GOA groundfish fisheries; and provide for adaptive management by continuing to specify OY as a range.

Alternative 2 Less Precautionary Management Policy: A less precautionary management policy (i.e. more aggressive harvest policy) would be implemented based upon the concept that the present policy is overly conservative and that higher harvests could be taken without threat of overfishing the target groundfish stocks. This policy assumes that fishing at the recommended levels would have no adverse impact on the environment, except in specific cases that are generally known. The objectives of this policy are to prevent overfishing by setting an OY cap at the sum of OFL or the sum of the ABCs for each species and provide for adaptive management by continuing to specify OY as a range.

Alternative 3 More Precautionary Management Policy: This policy would seek to accelerate the existing precautionary management measures through community or rights-based management, ecosystem-based management principles and, where appropriate and practicable, increase habitat protection and impose additional bycatch constraints. Under this approach, additional conservation management measures would be taken as necessary to respond to social, economic, or conservation needs. Additional measures would be taken if scientific evidence indicated that the fishery was negatively impacting the "environment", not just a population of a given species. The objectives of this policy are to: adopt conservative harvest levels for multi-species and single-species fisheries; provide for adaptive management by continuing to specify OY as a range or a formula; initiate a scientific review of the adequacy of F_{40}, and implement improvements accordingly; and to continue to collect scientific information and improve upon MSSTs including obtaining biological information necessary to move Tier 4 species into Tiers 1-3 in order to obtain MSSTs.

Alternative 4 Highly Precautionary Management Policy: This policy would require that the user of the resource demonstrate that the intended use would not have a detrimental effect on the environment before significant fishing could be allowed. The policy, as illustrated by its FMP framework, would be to impose very restrictive conservation and management measures that would only be modified or relaxed when additional, reliable scientific information became available. It would involve a strict interpretation of the precautionary principle. Management discussions would involve and be responsive to the public, but decreased emphasis would be placed on industry and community concerns, and more emphasis would be placed on ecosystem concerns and principles, including the identification and incorporation of non-consumptive use values. The overall premise is that fishing does produce adverse impacts on the environment, but due to a lack of information and uncertainty, little is known about these impacts. The objectives of this policy are to prevent overfishing by transitioning from single-species to ecosystem-oriented management of fishing activities and to close an additional 20 to 50 percent of known spawning areas of target species across the range of the stock to protect the productivity and genetic diversity.

3.1 Alternative 1 – Continue Management Under the Current Risk Averse Management Policy

In the context of the TAC-setting process, this alternative is based on the premise that the best scientific information available is typically sufficient to manage fisheries so that they achieve long-term average yields close to MSY without excessive risk to the fishery or ecosystem.

3.1.1 Description of Features Pertaining to the TAC-Setting Process

The background section presented a fairly detailed overview of the various elements that comprise the NPFMC harvest strategy as reflected in the FMPs. Here, attention will be focused more narrowly on those particular elements of the harvest strategy, which differ in at least one of the other alternatives.

Structure and Composition of Management Categories. The FMPs define four management categories for which catch is constrained by various regulatory mechanisms: Target Species, Prohibited Species, Other Species, and Forage Fish Species. In addition to these four management categories, the FMPs define a "Nonspecified Species" category for which catch is not constrained by any regulatory mechanism (this category is composed of stocks which are of no current economic value and which are taken by the groundfish fishery only as bycatch). Stocks can be moved from one management category into another only by FMP amendment. Within the Target Species category, stocks are managed either individually or as part of a stock complex. Stocks within the Target Species category can be added to or removed from a stock complex within the same category as part of the TAC-setting process (i.e., without an FMP amendment).

OFL and ABC. The FMPs specify OFL and maxABC by means of a tier system wherein the amount of information available for a given stock or stock complex determines the formula that is used to define F_{OFL} and *max* F_{ABC} (Tiers 1-5) or OFL and maxABC directly (Tier 6). The tier system is configured such that maxABC is always less than OFL except at very low stock sizes (where both maxABC and OFL are zero). The FMPs require that ABC be set between zero and maxABC. One of the central features of Tiers 1-3 is that F_{OFL} and *max* F_{ABC} decrease linearly with biomass whenever biomass falls below a tier-specific reference level. Most individual stocks are currently managed under Tier 3, where *max* F_{ABC} equals $F_{40\%}$ if biomass is above $B_{40\%}$. In Tier 1 (but not in any other tier), greater statistical uncertainty automatically results in a lower maxABC. This adjustment implies a fixed level of risk aversion and is computed using the statistical uncertainty surrounding both the estimate of projected stock size and the estimate of F_{MSY}.

OY and TAC. The FMPs specify OY as a range, which is aggregated across all stocks and does not vary with biomass. Within the Target Species category, a separate TAC is set for each individually managed stock and each stock complex. A single TAC is set for the entire Other Species category. No TAC is set for the Prohibited Species, Forage Fish Species, or Nonspecified Species categories. Although the FMPs require the sum of the individual TACs to fall within the OY range, they do not otherwise constrain individual TACs. In practice, however, individual TACs are never set higher than the corresponding ABCs. The FMP gives the Regional Administrator authority to close an area to directed fishing for a stock or stock complex whose remaining TAC is needed as bycatch in other directed fisheries. If a TAC is reached, the FMP requires the Regional Director to publish a notice declaring that stock or stock complex to be prohibited, in which case any further catches of that stock or stock complex must be discarded.

MSST. In practice, the status of each stock in Tiers 1-3 is examined annually in the SAFE reports with respect to the MSST definition contained in the NSGs, but no MSSTs are specified in the FMPs for stocks in Tiers 1-3 and no MSSTs are specified anywhere for stocks in Tiers 4-6.

Ecosystem Considerations. The FMPs prohibit directed fishing for forage species. Regulations require the directed fishery for any stock of pollock, Pacific cod, or Atka mackerel (key Steller sea lion prey species) to close if the biomass of that stock is projected to be less than or equal to $B_{20\%}$ during the fishing year. Traditionally, the NPFMC has encouraged research regarding indicators of ecosystem health, but the conditions under which such indicators might actually be used in the TAC-setting process are unclear.

3.1.2 Evaluation of Policy from a Single-Species Perspective

Structure and Composition of Management Categories. In the context of the TAC-setting process, the central features of the existing management categories are that some stocks are afforded the protection of a stock-specific catch limit, other stocks are afforded the protection of a complex-specific catch limit, while the stocks in the Nonspecified Species category are not protected by any catch limit (based on the understanding that stocks in that category are taken in such small amounts that no catch limit is necessary). Recently, attention has been focused on the possibility of removing certain individual stocks or groups of stocks from their respective stock complexes, affording them the additional protection of a stock-specific or group-specific catch limit. In fact, the NPFMC has taken this step several times in recent years, for example, by sequentially removing rock sole, flathead sole, and Alaska plaice from the "other flatfish" complex in the BSAI. However, concern has been expressed regarding the absence of an identifiable policy governing such decisions. In addition, comparatively little attention has been focused on the composition of the Nonspecified Species category. Presently, a committee composed of representatives from the SSC and Plan Teams is working to develop a draft policy that could be used to structure the management categories in a more consistent and scientifically justifiable manner.

OFL and ABC. Table 2 (reproduced from Goodman *et al.* 2002) lists the stocks and stock complexes comprising the Target Species and Other Species categories in each region, together with the tier assignment, OFL, *max*ABC, ABC, and other quantities for each in 2001. The relationships between these quantities can be summarized as follows:

- The maxABCs were always set below the OFLs, resulting in values, which averaged about 80 percent (range: 60-90 percent) of the OFLs.

- The ABCs were often set below the maxABCs, resulting in values, which averaged about 75 percent (range: 10-85 percent) of the OFLs.

In the GOA, none of the 16 stocks or stock complexes were assigned to Tiers 1 or 2; seven were placed in Tier 3; five were in Tier 4 or Tiers 4-5 (some stocks in a complex were managed under Tier 4 while the other members of the complex were managed under Tier 5); and four were assigned to Tiers 5, 5-6, or 6. Thus, a plurality of GOA stocks and complexes was managed under Tier 3. A similar situation existed in the BSAI region. In the BSAI, one stock (Bering Sea pollock) had sufficient information to be assigned to Tier 1. Of the remaining 20 stocks or stock complexes, 12 were in Tier 3; seven were placed in Tier 5 or 5-6; and squid were placed in Tier 6. Thus, a majority of BSAI stocks and complexes was managed under Tier 3. As discussed earlier, $F_{40\%}$ plays a key role in the Tier 3 maxABC control rule.

Table 2 Comparison of FMP Frameworks Regarding the TAC-Setting Process

Alt 1	Alt 2		Alt 3		Alt 4	
1	2.1	2.2	3.1	3.2	4.1	4.2
Set ABC < OFL Sum of TAC has to be within OY range	Set ABC = OFL Sum of TAC has to be within OY range	Set ABC < OFL Same as 2.1	Set ABC < OFL Set TAC =<ABC for all targets and "other spp." category	Same as 3.1 Same as 3.1	No changes from Alt 1 No changes from Alt 1	No changes from Alt 1 TAC = 0 for all species unless fisheries are proven to have no adverse effect on the environment
OY specified as range for BSAI: 1.4 - 2.0 mill mt and OY specified as range for GOA: 116,000 - 8000,000 mt; BSAI OY cap: If the sum of TAC > 2 mill mt then TAC will be adjusted down	OY specified as range; OY Cap = sum of OFL	OY specified as range; OY cap = sum of ABCs	OY specified as range for BSAI: 1.4 - 2.0 mill mt and OY specified as range for GOA: 116,000 - 800,000 mt; BSAI OY cap: If the sum of TAC > 2 mill mt then TAC will be adjusted down (No changes from Alt 1)	No OY range in plan; OY = TAC which is =<ABC TAC is fishery specific	No OY range in plan; OY = TAC which is =<ABC TAC is fishery specific	OY = 0; No fishery
B_{20} rule for prey species (pollock, P. cod, Atka mackerel)	No changes from Alt 1	No changes from Alt 1	B_{20} rule for prey species (pollock, P. cod, Atka mackerel) (No changes from Alt 1)	Revise harvest control rule by incorporating a constant buffer	Set F_{75} for prey species (pollock, P. cod, Atka mackerel)	TAC = 0 for all species
ABC tier system (Amendment 56)	OFL management (Amendment 56 OFL definitions with inflection points removed in tiers 1-3)	No changes from Alt 1	Review F_{40} and adapt ABC tier system where F_{40} is maximum permissible for stocks without estimate of MSY	When possible, biological reference points based on species specific production patterns and ecosystem considerations	Set F_{60-80} for vulnerable (e.g., long-life, slow-growing) species (will use F_{60} as proxy)	TAC = 0 for all species
No directed fishery for forage fish (forage fish ban; Amendment 36/39)	No forage fish ban	No changes from Alt 1	No directed fishery for forage fish (forage fish ban, Amendment 36/39; No changes from Alt 1)	Same as 3.1	No directed fishery for forage fish (forage fish ban, Amendment 36/39; No changes from Alt 1)	Same as 4.1

Table 2 (Cont.) Comparison of FMP Frameworks Regarding the TAC-Setting Process.

Alt 1	Alt 2		Alt 3		Alt 4	
1	2.1	2.2	3.1	3.2	4.1	4.2
Specify MSSTs for Tier 1-3 stocks	No changes from Alt 1	No changes from Alt 1	Identify minimum required elements, resources, cost and a realistic time frame necessary to establish MSSTs for additional stocks and prioritize a list of candidate stocks	Initiate analysis of MSSTs for priority stocks based on the timeframe determined by additional availability of required resources	Adopt MSSTs appropriate to the harvest policy for each stock, with B_{40} as the limit (rather than the target)	No changes from Alt 1
Set group TAC for 'other species'	No changes from Alt 1	No changes from Alt 1	Break sharks and skates out of "other species" group for TAC setting (Amendment 63/63)	Break sharks and skates and additional groups out of "other species" group for TAC setting	Least Abundant Species Aggregate TAC: e.g., TAC of species complex is based on the TAC of the least abundant member of the group	TAC = 0 for all species
			Develop criteria for breaking out a species from a species complex	Develop criteria to bring a non-specified species into a managed category	Where possible, break species out of the complex	
Precautionary adjustments exist, but vary with uncertainty only in tier 1	OFL management only	No changes from Alt 1	Conduct F_{40} review and adopt appropriate measures	Develop, implement and update as necessary, procedures to account for uncertainty in estimating ABC	Incorporate survey variance and uncertainty in ABC by a survey coefficient of variation for each stock	In the face of uncertainty, set TAC = 0 for all species unless fisheries are proven to have no adverse effect on the environment
Develop ecosystem indicators for future use in TAC-setting	No ecosystem indicators	No changes from Alt 1	Develop criteria for using key ecosystem indicators in TAC-setting	Adopt, update as necessary, and use ecosystem indicators in TAC-setting	Evaluate a range of ABCs using the lower bound of a confidence limit to address uncertainties in stock assessment advice	
Target species closures when harvest limit reached	No changes from Alt 1	No changes from Alt 1	No changes from Alt 1	No changes from Alt 1	No changes from Alt 1	Harvest limit = 0

There is a fairly widespread consensus in the scientific literature that, for a range of typical groundfish life histories, $F_{40\%}$ is a safe harvest rate. However, Goodman *et al.* (2002) raised concerns regarding the use of $F_{40\%}$ in managing the BSAI and GOA rockfish species. This concern was based mainly on results obtained by MacCall (2002) and Clark (2002) working with West Coast rockfish. However, only a few rockfish stocks in Alaska are being managed under a tier in which $F_{40\%}$ plays a role, and those which are managed in one of those tiers (Pacific ocean perch and GOA thornyhead) appear to be doing well. Dorn (2002) studied Alaska rockfish stocks in addition to West Coast stocks and found that, although $F_{40\%}$ was not always a safe harvest rate for the West Coast stocks, it appeared to be safe for the Alaska stocks included in the study. Thus, the concern raised by Goodman *et al.* (2002) appears to be more germane to rockfish stocks which are currently managed in Tier 5 but which might be managed under a different tier in the future, in which case the key question is whether the Tier 5 rockfish stocks behave more like other Alaska rockfish stocks or more like West Coast rockfish stocks. Goodman *et al.* (2002) also note that the Tier 3 maxABC control rule is not directly comparable to the control rules used in the studies by MacCall (2002) and Clark (2002). Under the Tier 3 control rule, fishing mortality decreases linearly with stock size if the biomass falls below $B_{40\%}$, whereas it was assumed in the West Coast rockfish studies that harvest rates would be kept constant regardless of stock size. All else being equal, the Tier 3 control rules are more conservative than the $F_{40\%}$ strategies in the referenced studies of West Coast rockfish.

Over time, the evolution of the tier system has tended towards increasing conservatism. By the standards of the world's other large commercial fisheries, the current tier system is conservative.

OY and TAC. In addition to OFL, maxABC, and ABC, Table 2 also lists TAC and the 1997-2000 average ratio of catch to TAC for each stock and stock complex in the Target Species and Other Species categories. The relationships between these quantities can be summarized as follows:

- The TACs were often set below the ABCs, resulting in values, which averaged about 65 percent (range: 0-85 percent) of the OFLs.

- On average, catches exceeded TACs only rarely. The median ratio of catch to TAC (averaged over the period 1997-2000) was about 60 percent for both the BSAI and GOA. The range of the ratios across areas and species was 21-112 percent, with the highest ratio coming from the GOA sablefish fishery, where catches exceeded TACs in three of the four years examined.

As noted earlier, the MSA states that OY is to be prescribed "on the basis of the MSY from the fishery, as reduced by any relevant economic, social, or ecological factor." According to the NSGs, this requirement means, in part, that the OY in any given year "must always be less than or equal to the harvest level that would be obtained under the MSY control rule." Thus, in order to determine whether the OY specification complies with the MSA, it is necessary to know the form of the MSY control rule. This is problematic in the case of the BSAI and GOA Groundfish FMPs, because the NPFMC declined to specify an MSY control rule in Amendment 56. Based on the methods used to specify the current OY range and the fact that it does not vary with biomass, it could be inferred that the NPFMC's implicit MSY control rule is of the "constant catch" form. However, this interpretation would mean that the OFL control rules in at least some of the tiers violate the NSGs' requirement that the MSST not exceed the MSY control rule (in Tiers 1-2, for example, OFL exceeds MSY whenever biomass exceeds B_{MSY}). On the other hand, if it is assumed that the OFL control rules correspond to the NPFMC's implicit MSY control rule, then the adequacy of the current OY specification is called into question, because the entire OY range will exceed the harvest associated with the MSY control rule if biomass is low enough.

Previous reviews have identified similar concerns regarding the current OY specifications. For example, Goodman *et al.* (2002) compared the 1999 OFLs with the current OY specifications and found that, although the aggregate BSAI OFL of 3.7 million mt was higher than the BSAI OY range (1.4 to 2.0 million mt), the aggregate GOA OFL of 779,000 mt was within the GOA OY range (116,000 to 800,000 mt), leading the authors to recommend that the NPFMC might consider a review of the existing OY definitions so that they could be made consistent with the MSA in a more explicit way. In a draft review of the current OY specifications, Thompson (1998) concluded, "The GOA OY specification generally fails to address protection of marine ecosystems and may fail to insure that OY does not exceed MSY. The BSAI OY specification clearly attempts to address protection of marine ecosystems (though whether the attempt is sufficient is probably debatable) and most likely insures that OY does not exceed MSY. However, the fact that neither of the OY specifications has been formally reviewed for at least 10 years may mean that they need to be reanalyzed anyway."

MSST. As noted above, the NSGs require FMPs to specify MSST whenever possible, but the BSAI and GOA Groundfish FMPs do not specify MSST, although the status of each stock in Tiers 1-3 is examined annually in the SAFE reports with respect to the MSST definition contained in the NSGs, using $B_{35\%}$ as a proxy for Tier 3 stocks even though no such proxy is identified in the tier system, all of which has caused considerable confusion and controversy. Confusion and controversy aside, however, the lack of an FMP-specified MSST for Tiers 1-3 has had no practical impact on the management or health of the stocks. As shown by the annual examination in the SAFE reports, no stock in Tiers 1-3 has ever fallen below the MSST since the examination began in 1999. Furthermore, in the event that a stock ever did fall below the MSST, the existing maxABC control rules might very well provide an acceptable rate of rebuilding under the MSA, meaning that no change in harvest strategy would be required.

Tiers 4-6 provide a different set of problems. These three tiers apply by definition to those stocks and stock complexes for which the available information is insufficient to estimate a reference biomass level such as B_{MSY} or $B_{35\%}$, making it difficult to determine directly whether such a stock or stock complex is above its MSST. An early draft of Amendment 56 included an alternative, which identified various proxies for B_{MSY} with fewer information requirements than a direct estimate of B_{MSY} or $B_{35\%}$, but the NPFMC asked that this alternative be omitted from the final draft. Instances of a stock or stock complex moving from Tiers 4-6 to Tiers 1-3 have been few since implementation of Amendment 56.

3.1.3 Evaluation of Policy from an Ecosystem Perspective

As discussed earlier, many elements of the existing harvest strategy have implications for the ecosystem, at least indirectly, and several were adopted with EC explicitly in mind, including the BSAI OY range, the prohibition of directed fishing for forage species, and the required closure of the directed fishery for any stock of pollock, Pacific cod, or Atka mackerel that falls below $B_{20\%}$. However, the actual impacts of these measures on the ecosystem are largely unknown.

Although the present FMP policy includes the goal of developing ecosystem indicators for future use in TAC setting, the conditions under which such indicators might actually be used in the TAC-setting process are unclear. The existing policy allows TAC to be set below ABC for a wide variety of reasons including EC. In practice, however, decisions to set TAC below ABC are seldom accompanied by explicit rationale of any kind, let alone an indication of the extent to which they are due to EC.

Goodman *et al.* (2002) concluded that, while the existing system had the potential to be highly considerate of ecosystem needs, the available data could be used for a more ambitious and formalized decision system, which might be more explicitly considerate of ecosystem needs. However, the authors of the study qualified this by observing that the available data have not proven sufficient to demonstrate conclusively whether more protection is actually needed.

3.1.4 Conclusions

The existing policy is conservative overall. It has resulted in catches that have been, on average, below those that would have been obtained from a strict F_{MSY} policy, for example. However, some concern has been raised regarding certain features of the existing policy, including the following: 1) The legal adequacy of the existing OY specifications is not clear; 2) The FMPs do not specify an MSST; 3) Some of the fishing mortality rates resulting from the existing policy have been found to be too high for certain stocks in other parts of the country; 4) The impacts of the existing policy on other components of the ecosystem are largely unknown.

3.2 Alternative 2 – Adopt a More Aggressive Management Policy

In the context of the TAC-setting process, this alternative is based on the premise that the best scientific information available is typically sufficient to manage fisheries so that they achieve long-term average yields very close or equal to MSY without excessive risk to the fishery or ecosystem.

3.2.1 Description of Features Pertaining to the TAC-Setting Process

The ways in which Alternatives 2.1 and 2.2 differ with respect to Alternative 1 are listed below.

Structure and Composition of Management Categories. Differences under Alternative 2.1: None. Differences under Alternative 2.2: None.

OFL and ABC. Differences under Alternative 2.1: F_{OFL} would no longer vary with biomass over any portion of the range in Tiers 1-3 and ABC would be adjusted upward so as to equal OFL in all tiers. Differences under Alternative 2.2: None.

OY and TAC. Differences under Alternative 2.1: OY would be specified annually as a range aggregated across all stocks and would extend from the lower end of the current range to either the sum of the OFLs or the upper end of the current range, whichever is greater. Differences under Alternative 2.2: OY would be specified annually as a range aggregated across all stocks and would extend from the lower end of the current range to either the sum of the ABCs or the upper end of the current range, whichever is greater.

MSST. Differences under Alternative 2.1: None. Differences under Alternative 2.2: None.

Ecosystem Considerations. Differences under Alternative 2.1: Directed fishing of forage species would be permitted and use of ecosystem indicators in the TAC-setting process would be prohibited. Differences under Alternative 2.2: None.

3.2.2 Evaluation of Policy from a Single-Species Perspective

By making F_{OFL} independent of biomass over the entire range in Tiers 1-3 and adjusting ABC upward so as to equal OFL in all tiers, Alternative 2.1 would result in higher OFLs for all stocks in Tiers 1-3 that are below their tier-specific reference levels (B_{MSY} in Tiers 1-2, $B_{40\%}$ in Tier 3) and higher ABCs for all stocks, relative to values that would be obtained under Alternative 1. This change would also make it more likely for stocks to be classified as "overfished," which would in turn require the implementation of rebuilding plans that would constrain harvest to some level lower than ABC.

By specifying OY annually as a range that can extend as high as the sum of the OFLs (under Alternative 2.1) or the sum of the ABCs (Alternative 2.2), Alternative 2 would allow for the possibility of higher TACs than would be permissible under Alternative 1. Whether Alternative 2 would actually result in higher overall catches than Alternative 1 would depend in part on a variety of factors such as the biomass of the stocks, the relationship between TAC and ABC, and the extent to which management measures other than the OY cap (PSC limits, etc.) would constrain future harvests under Alternative 2.

Also, the revisions to the OY specification proposed under Alternative 2 could give the impression that the implied MSY control rule is of the "constant F" form, an impression which would be reinforced under Alternative 2.1 by the fact that the OFL control rule under this alternative is also of the "constant F" form with F set equal to F_{MSY} or an F_{MSY} proxy wherever possible. Scenarios could be imagined wherein the biomass of the groundfish complex is much lower than at present and wherein the entire OY range exceeds the sum of the catches associated with an F_{MSY} control rule, thus calling into question whether this provision of Alternative 2 would comply with the NSGs' interpretation of the statutory relationship between OY and MSY.

3.2.3 Evaluation from an Ecosystem Perspective

By permitting directed fishing of forage species, Alternative 2.1 could result in higher harvests of forage species and, indirectly, result in decreased abundance of predator species including some target groundfish species, marine mammals, and sea-birds.

By prohibiting use of ecosystem indicators in the TAC-setting process, Alternative 2.1 would fail to mitigate any adverse impacts on the ecosystem that might arise if such impacts could not be detected using conventional stock assessments or other single-species approaches.

In addition to the above, many of the management measures proposed under Alternative 2 and discussed previously from a single-species perspective could also have impacts from an ecosystem perspective. Under certain circumstances, these measures have the potential to result in higher catches of individual species than would occur under Alternative 1. Basically, any of the management measures that would result in higher harvests would also alter the community structure of the affected ecosystem to some extent. This would occur by several mechanisms. First, higher catches would result directly in a smaller remaining biomass of the targeted stocks as well as those stocks taken as bycatch. Second, higher catches would probably be associated with higher fishing effort, which would result in greater impacts on the habitat. Third, impacts resulting from either of the first two mechanisms would tend to propagate indirectly through the ecosystem, resulting in changes in the biomass of various species, including non-target species such as marine mammals and birds. However, as discussed above, it is difficult to predict from qualitative considerations alone whether Alternative 2 would necessarily result in higher catches than Alternative 1.

3.2.4 Conclusions

Alternative 2 is intended to provide a less precautionary management policy than currently exists under Alternative 1. It spans a spectrum of possible approaches. One possible approach, represented by Alternative 2.2, is identical to Alternative 1 except for a provision, which would allow the upper end of the OY range to be as high as the sum of the ABCs. Alternative 2.1 represents another possible approach, one which provides greater contrast with Alternative 1. Under Alternative 2.1, the upper end of the OY range could be as high as the sum of the OFLs, various non-precautionary adjustments would be made to the OFL control rule and the relationship between OFL and ABC, directed fishing of forage species would be permitted, and use of ecosystem indicators in the TAC-setting process would be prohibited. While each of these features of Alternatives 2.1 and 2.2 carries the potential for increased harvests relative to what might be achieved under Alternative 1, it is not possible to determine whether such increases would actually be realized on the basis of qualitative considerations alone.

3.3 Alternative 3 – Adopt a More Precautionary Management Policy

In the context of the TAC-setting process, this alternative is based on the premise that the best scientific information available is typically sufficient to determine how far below MSY fisheries should be managed in order to prevent excessive risk to the fishery or ecosystem.

3.3.1 Description of Features Pertaining to the TAC-Setting Process

The ways in which Alternatives 3.1 and 3.2 differ with respect to Alternative 1 are listed below.

Structure and Composition of Management Categories. Differences under Alternative 3.1: Sharks and skates would be removed from the Other Species category and given their own TACs, and criteria for removing other stocks from a stock complex within the Target Species category would be developed. Differences under Alternative 3.2: Sharks, skates, and additional groups would be removed from the Other Species category and given their own TACs, and criteria for moving stocks from the Nonspecified Species category into another management category would be developed.

OFL and ABC. Differences under Alternative 3.1: The tier system would be re-examined in light of the findings presented by Goodman *et al.* (2002), but any future changes to the tier system would continue to allow *max* F_{ABC} in Tier 3 to be as high as $F_{40\%}$ for any stock whose biomass is sufficiently large. Differences under Alternative 3.2: Biological reference points used in the tier system would be made taxon-specific where appropriate (for example, *max* F_{ABC} for Tier 3 rockfish stocks could be capped at $F_{60\%}$ rather than $F_{40\%}$), and scientifically justifiable methods for adjusting maxABC to account for statistical uncertainty in various tiers would be developed, implemented, and updated as appropriate.

OY and TAC. Differences under Alternative 3.1: The FMP would require that the TAC for each stock or stock complex be set no higher than the corresponding ABC. Differences under Alternative 3.2: The FMP would require that the TAC for each stock or stock complex be set no higher than the corresponding ABC; OY would be specified separately for each stock or stock complex and set equal to the respective TAC.

MSST. Differences under Alternative 3.1: MSSTs for stocks in Tiers 1-3 would be specified in the FMPs, the resources and time frame necessary to specify MSSTs for stocks in Tiers 4-6 would be identified, and a list of Tier 4-6 stocks prioritized for future MSST specification would be developed. Differences under

Alternative 3.2: MSSTs for stocks in Tiers 1-3 would be specified in the FMPs, the resources and time frame necessary to specify MSSTs for stocks in Tiers 4-6 would be identified, a list of Tier 4-6 stocks prioritized for future MSST specification would be developed, and MSSTs would be specified in the FMPs for priority stocks in Tiers 4-6 as the necessary resources become available.

Ecosystem Considerations. Differences under Alternative 3.1: Criteria for future use of ecosystem indicators in the TAC-setting process would be developed. Differences under Alternative 3.2: A set of ecosystem indicators would be formally adopted and used in the TAC-setting process.

3.3.2 Evaluation from a Single-Species Perspective

By developing criteria for removing stocks from a stock complex within the Target Species category, Alternative 3.1 would confer added consistency on decisions regarding which stocks to manage individually. Similarly, by developing criteria for moving stocks from the Nonspecified Species category into another category, Alternative 3.2 would focus attention on the possibility of conferring increased protection on individual non-target stocks for which catch is currently unconstrained by any regulatory mechanism.

By re-examining the tier system in light of the findings presented by Goodman *et al.* (2002), Alternative 3.1 would provide an opportunity to make further precautionary improvements to an already-precautionary system. Alternative 3.2 would go further by committing to the use of taxon-specific reference points where appropriate and by reformulating the harvest control rules in various tiers (not just Tier 1) so that greater statistical uncertainty automatically translates into an appropriately reduced maxABC. Whether adoption of any of the changes to the tier system proposed under Alternative 3 would result in lower overall catches relative to Alternative 1 depends on a variety of factors such as the biomass of the stocks, the relationship between TAC and maxABC, and the extent to which management measures other than the harvest control rules (OY cap, PSC limits, etc.) would constrain future harvests under Alternative 1.

By making the relationship $TAC \leq ABC$ into an FMP requirement rather than just a tradition, Alternatives 3.1 and 3.2 would give added assurance that this relationship will continue to hold in the future. Also, compared to Alternative 1, Alternative 3.2 would specify OY in a way that more clearly satisfies the single-species requirements of the MSA: If the OFL control rule is interpreted as the MSY control rule, then the relationships $OY=TAC \leq ABC<OFL$ specified under Alternative 3.2 would assure that OY is always less than the catch corresponding to the MSY control rule.

By specifying MSSTs for stocks in Tiers 1-3 in the FMP, Alternatives 3.1 and 3.2 would bring the FMP more clearly into compliance with the single-species requirements of the NSGs. However, because the status of each stock in these tiers is already evaluated in the SAFE reports with respect to the MSST definition contained in the NSGs, this probably would not result in any new constraints on harvests in the foreseeable future.

3.3.3 Evaluation from an Ecosystem Perspective

By removing sharks and skates from the Other Species category and giving them their own TACs, Alternatives 3.1 and 3.2 would confer greater protection on these two species groups (Alternative 3.2 would also remove additional groups from the Other Species category).

By developing criteria for future use of ecosystem indicators in the TAC-setting process, Alternative 3.1 would clarify what additional research needs to be undertaken in order to integrate EC into the setting of TACs. Alternative 3.2 would go further by moving directly to the adoption of a set of ecosystem indicators and using them in the TAC-setting process.

In addition to the above, many of the management measures proposed under Alternative 3 and discussed previously from a single-species perspective could also have impacts from an ecosystem perspective. Under the right circumstances, these measures have the potential to result in either higher or lower catches of individual species than would occur under Alternative 1. Basically, any of the management measures that would result in different harvest levels would also alter the community structure of the affected ecosystem to some extent. This would occur by several mechanisms. First, different catch levels would result directly in different remaining biomasses of the targeted stocks as well as those stocks taken as bycatch. Second, different catch levels would probably be associated with different levels of fishing effort, which would result in different impacts on the habitat. Third, impacts resulting from either of the first two mechanisms would tend to propagate indirectly through the ecosystem, resulting in changes in the biomass of various species, including non-target species such as marine mammals and birds. However, as discussed above, it is difficult to predict from qualitative considerations alone whether aggregate catches obtained under Alternative 3 would be higher or lower than aggregate catches obtained under Alternative 1.

3.3.4 Conclusions

Alternative 3 is intended to provide a more precautionary management policy than currently exists under Alternative 1. Like Alternative 2, Alternative 3 spans a spectrum of possible approaches. Unlike the two examples considered under Alternative 2, however, both Alternative 3.1 and Alternative 3.2 differ from Alternative 1 in a variety of ways. The "more precautionary" designation here refers to the application of a higher degree of precaution where it is needed. It should be emphasized that this is not the same thing as reducing harvest rates across the board. For example, under Alternative 3, it might be determined that $F_{35\%}$ is a satisfactory F_{MSY} proxy for all stocks except certain rockfish, in which case a special set of control rules might be established for those rockfish while leaving the existing control rules in place for the other stocks. Thus, as the various features of Alternative 3 work together, it is possible that aggregate catches could be either higher or lower than under Alternative 1, but a greater degree of protection would be afforded to the stocks that need it most, while the remaining stocks would continue to be harvested conservatively. Alternative 3 would also be more proactive than Alternative 1 in terms of incorporating EC into the TAC-setting process.

3.4 Alternative 4 – Adopt aHighly Precautionary Management Policy

In the context of the TAC-setting process, this alternative is based on the premise that the best scientific information available is typically insufficient to manage fisheries so that they achieve long-term average yields anywhere close to MSY without excessive risk to the fishery or ecosystem.

3.4.1 Description of Features Pertaining to the TAC-Setting Process

The ways in which Alternatives 4.1 and 4.2 differ with respect to Alternative 1 are listed below.

Structure and Composition of Management Categories. Differences under Alternative 4.1: Individual stocks would be removed from stock complexes within the Target Species category whenever possible. Differences under Alternative 4.2: None.

OFL and ABC. Differences under Alternative 4.1: The *max* F_{ABC} would be capped at $F_{75\%}$ for all stocks of pollock, Pacific cod, Atka mackerel, and rockfish managed under Tiers 1-3, and the *max* F_{ABC} for each stock or stock complex in Tiers 1-5 would be adjusted downward based on the lower bound of a confidence interval surrounding the survey biomass estimate for that stock or stock complex. Differences under Alternative 4.2: None.

OY and TAC. Differences under Alternative 4.1: The FMP would require that the TAC for each stock be set no higher than the corresponding ABC and would require that the TAC for a stock complex be determined by applying the appropriate maxABC control rule to each of the component stocks and then setting the TAC equal to the minimum of the resulting values; OY would be specified separately for each stock or stock complex and set equal to the respective TAC. Differences under Alternative 4.2: The FMP would require that each individual TAC be set at zero unless it is proven that a higher TAC would have no adverse effect on the environment; OY would be specified separately for each stock or stock complex and set equal to the respective TAC.

MSST. Differences under Alternative 4.1: An MSST would be specified in the FMP for all tiers, and would be set equal to $B_{40\%}$ for Tier 3. Differences under Alternative 4.2: None.

Ecosystem Considerations. Differences under Alternative 4.1: None. Differences under Alternative 4.2: None.

3.4.2 Evaluation from a Single-Species Perspective

By removing individual stocks from stock complexes within the Target Species category whenever possible, Alternative 4.1 would confer added protection on those stocks relative to Alternative 1, because harvests of each removed stock would be limited by a stock-specific TAC rather than a complex-wide TAC.

By capping *max* F_{ABC} at $F_{75\%}$ for all stocks of pollock, Pacific cod, Atka mackerel, and rockfish managed under Tiers 1-3, Alternative 4.1 would result in lower *max* F_{ABC} values for all stocks of these species managed under Tier 3, compared to Alternative 1. For stocks in Tiers 1-2, the resulting *max* F_{ABC} values could, in principle, be either higher or lower than they would be under Alternative 1; however, based on the very limited experience to date (only one stock has ever been managed under Tiers 1-2), it appears likely that they would be lower. By adjusting *max* F_{ABC} for each stock or stock complex in Tiers 1-5 downward based on the lower bound of a confidence interval surrounding the respective survey biomass estimate, Alternative 4.1 would incorporate some amount of risk aversion into the computation of *max* F_{ABC} for those stocks. The resulting *max* F_{ABC} values for stocks in Tiers 1-5 would be uniformly lower than they would be under Alternative 1. However, it is not clear what scientific justification the specific adjustment would have, and it is likely that the implied level of risk aversion would vary between stocks, even if their respective survey biomass estimates were equally precise (or imprecise). Whether adoption of either of the changes to *max* F_{ABC} proposed under Alternative 4.1 would result in lower overall catches relative to Alternative 1 depends on a variety of factors such as the biomass of the stocks, the relationship between TAC and maxABC, and the extent to which management measures other than the harvest control rules (OY cap, prohibited species catch limits, etc.) would constrain future harvests under Alternative 1.

By making the relationship TAC≤ABC into an FMP requirement rather than just a tradition, Alternative 4.1 would give added assurance that this relationship will continue to hold in the future. By requiring that the TAC for a stock complex be determined by applying the appropriate maxABC control rule to each of the component stocks and then setting the TAC equal to the minimum of the resulting values, Alternative 4.1 would confer additional protection on these stocks, because it would preclude the possibility of harvesting any individual stock within a complex at a rate greater than would be allowed if it were removed from the complex and given its own TAC. By setting OY equal to TAC, Alternatives 4.1 and 4.2 would specify OY in a way that more clearly satisfies the single-species requirements of the MSA than does the OY specification contained in Alternative 1: If the OFL control rule is interpreted as the MSY control rule, then the relationships OY=TAC≤ABC<OFL specified under Alternative 4.1 would assure that OY is always less than the catch corresponding to the MSY control rule. By requiring that each individual TAC be set at zero unless it is proven that a higher TAC would have no adverse effect on the environment, Alternative 4.2 would confer complete protection on all stocks in the Target Species and Other Species categories.

By specifying MSSTs for stocks in all tiers in the FMP, Alternative 4.1 would bring the FMP more clearly into compliance with the single-species requirements of the NSGs. How this would be accomplished, however, is currently unclear. By setting the MSST equal to $B_{40\%}$ for all stocks in Tier 3, Alternative 4.1 would make it much more likely that individual stocks would be declared "overfished," even if the stocks were being harvested conservatively.

3.4.3 Evaluation from an Ecosystem Perspective

Many of the management measures proposed under Alternative 4 and discussed above from a single-species perspective could also have impacts from an ecosystem perspective. Under certain circumstances, some of these measures have the potential to result in much lower catches of individual species than might occur under Alternative 1. Basically, any of the management measures that would result in lower harvests would also alter the community structure of the affected ecosystem to some extent. This would occur by several mechanisms. First, lower catches would result directly in a larger remaining biomass of the targeted stocks as well as those stocks taken as bycatch. Second, lower catches would probably be associated with lower fishing effort, which would result in fewer impacts on the habitat. Third, impacts resulting from either of the first two mechanisms would tend to propagate indirectly through the ecosystem, resulting in changes in the biomass of various species, including non-target species such as marine mammals and birds. However, as discussed above, it is difficult to predict from qualitative considerations alone whether Alternative 4 would necessarily result in lower catches than Alternative 1. In the case of Alternative 4.1, the impact on overall catches relative to Alternative 1 would depend in part on a variety of factors such as the biomass of the stocks, the relationship between TAC and *max*ABC, and the extent to which management measures other than the harvest control rules (OY cap, prohibited species catch limits, etc.) would constrain future harvests under Alternative 1. In the case of Alternative 4.2, it seems safe to assume that overall catches would initially be much lower than under Alternative 1, but long-term catch levels under Alternative 4.2 would depend on factors such as the rate of growth in scientific understanding and the standards of proof used to determine safe harvest levels.

3.4.4 Conclusions

Alternative 4 is intended to provide a highly precautionary management policy. Like Alternatives 2 and 3, Alternative 4 spans a spectrum of possible approaches. One possible approach, represented by Alternative 4.1, suggests that harvesting should proceed very cautiously in the presence of uncertainty. Another possible

approach, represented by Alternative 4.2, suggests that harvesting should not proceed at all in the presence of uncertainty. In the context of the TAC-setting process, Alternative 4.1 proposes changes in many of the present management tools such as MSST, maxABC, ABC, TAC, and OY, whereas Alternative 4.2 focuses entirely on TAC and OY. Like Alternative 3, the precautionary adjustments proposed under Alternative 4 are aimed primarily at the individual stocks while aggregate management measures such as the current OY cap are relaxed, meaning that Alternative 4 would not necessarily guarantee lower aggregate harvests than Alternative 1 (although Alternative 4.2 seems likely to result in lower aggregate harvests, at least in the short run). Ecosystem effects of Alternative 4 would be mediated entirely through management of individual stocks and stock complexes. No provision is made for use of ecosystem indicators in the TAC-setting process.

4.0 Comparisons of Alternative Policies

As has been noted above, predicting how actual catches would compare between alternatives on the basis of qualitative considerations alone is a complicated undertaking. This is partly due to the fact that each of the alternatives except Alternative 1 embodies a spectrum of possible management approaches and partly due to the fact that each alternative permits a considerable degree of management flexibility. For example, although each of the alternatives sets or implies some sort of upper limit on individual TACs, none of the alternatives sets a lower limit on individual TACs, meaning that, under any of the alternatives, future individual TACs could be set anywhere between zero and some alternative-specific upper limit. Further complicating matters is the fact that, under Alternatives 1, 2.1, and 2.2, it would not be possible to set the individual TACs independently of one another because their sum would be constrained by the alternative-specific aggregate OY range. Thus, while it is possible to describe how management measures differ between alternatives, predicting how these management measures will translate into catches is difficult in the absence of some sort of quantitative analysis (see Chapter 4 of the Programmatic SEIS).

Although it is difficult to predict how actual catches would compare between alternatives on the basis of qualitative considerations alone, it is possible to describe how the various constraints on harvests compare between alternatives. Evaluated qualitatively in terms of their respective constraints on harvests, the alternatives may be ranked as follows, beginning with the least precautionary and progressing to the most precautionary:

Alternative 1: All of the existing constraints would be retained.

Alternative 2.1: Some of the existing constraints would be relaxed.

Alternative 2.2: All of the existing constraints would be retained, except that the upper end of the OY range would be allowed to increase.

Alternative 3.1: Some of the existing constraints would be tightened and criteria would be developed for using ecosystem indicators as part of the TAC-setting process. MSSTs for Tier 3 stocks would be specified in the FMPs, but this probably would not result in any new constraints on harvests in the foreseeable future.

Alternative 3.2: Some of the existing constraints would be tightened, some others would be modified in ways that are more precautionary when stocks are relatively vulnerable but potentially less precautionary under other circumstances (e.g., if a stock is shown to be highly

resilient to fishing or if biomass is high), and a set of ecosystem indicators would be formally adopted and used in the TAC-setting process. MSSTs for stocks in Tiers 1-3 and some other stocks would be specified in the FMPs, but this would probably not result in any new constraints on harvests for Tier 3 stocks in the foreseeable future.

Alternative 4.1: Some of the existing constraints would be tightened and some others would be modified in ways that are more precautionary when stocks are relatively vulnerable but potentially less precautionary under other circumstances (e.g., if biomass is high). MSSTs for all stocks would be specified in the FMPs and set equal to $B_{40\%}$ for all Tier 3 stocks, meaning that several Tier 3 stocks would be declared overfished, thus necessitating the development and implementation of rebuilding plans which could impose additional constraints.

Alternative 4.2: All of the existing constraints would be retained, except that the constraints on OY and TAC would be tightened to an extreme degree (OY and TAC would be set equal to zero unless it is proven that a higher catch would have no adverse effect on the environment).

Finally, while there are important differences between all of the alternatives, it should be remembered that a considerable degree of commonality exists in some cases as well. For example, with respect to the five subject areas addressed in the context of the TAC-setting process (structure and composition of management categories, OFL/ABC, OY/TAC, MSST, and EC), Alternatives 2.2 and 4.2 are identical to Alternative 1 with respect to four (SCMC, OFL/ABC, MSST, and EC), Alternative 2.1 is identical to Alternative 1 with respect to two (SCMC and MSST), and Alternative 4.1 is identical to Alternative 1 with respect to one EC. Only Alternatives 3.1 and 3.2 differ from Alternative 1 with respect to all five subject areas. Looked at another way, Alternative 1 is identical to at least one other alternative with respect to each of the five subject areas except OY/TAC. All of the alternatives differ from one another to some extent with respect to OY/TAC. Such commonality is expected, since each example FMP must be consistent with the MSA and NSGs.